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(54) **OPTICAL DISC DEVICE AND DISC IDENTIFICATION METHOD**

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G11B 7/00 (2006.01)

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369/116, 47.53, 275.3

See application file for complete search history.

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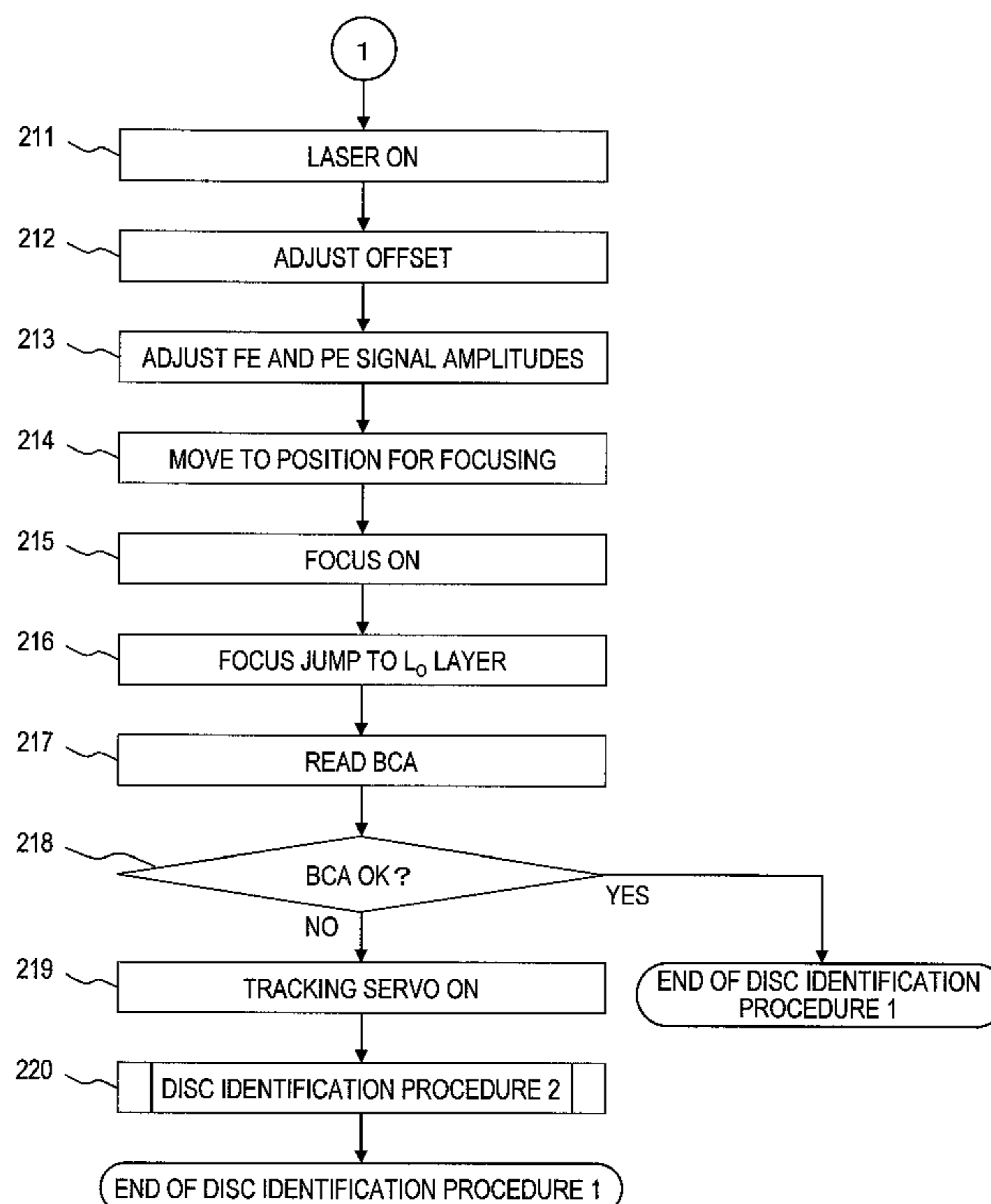
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(57) **ABSTRACT**

To identify the type of a loaded disc, there is provided an optical disc device, comprising: a light source driven by a drive signal with a high frequency signal superimposed; a detector for detecting return light emitted from the light source; and a controller for controlling the amplitude of the high frequency signal to be superimposed on the drive signal, the optical disc device being configured to read data from an optical disc loaded therein by a signal outputted from the detector, wherein: the controller causes the light source to irradiate the loaded optical disc with light in a condition in which a high frequency signal different from a high frequency signal for data reading is superimposed on the drive signal; and the controller identifies a type of the loaded optical disc based on the return light from the loaded optical disc.

10 Claims, 7 Drawing Sheets



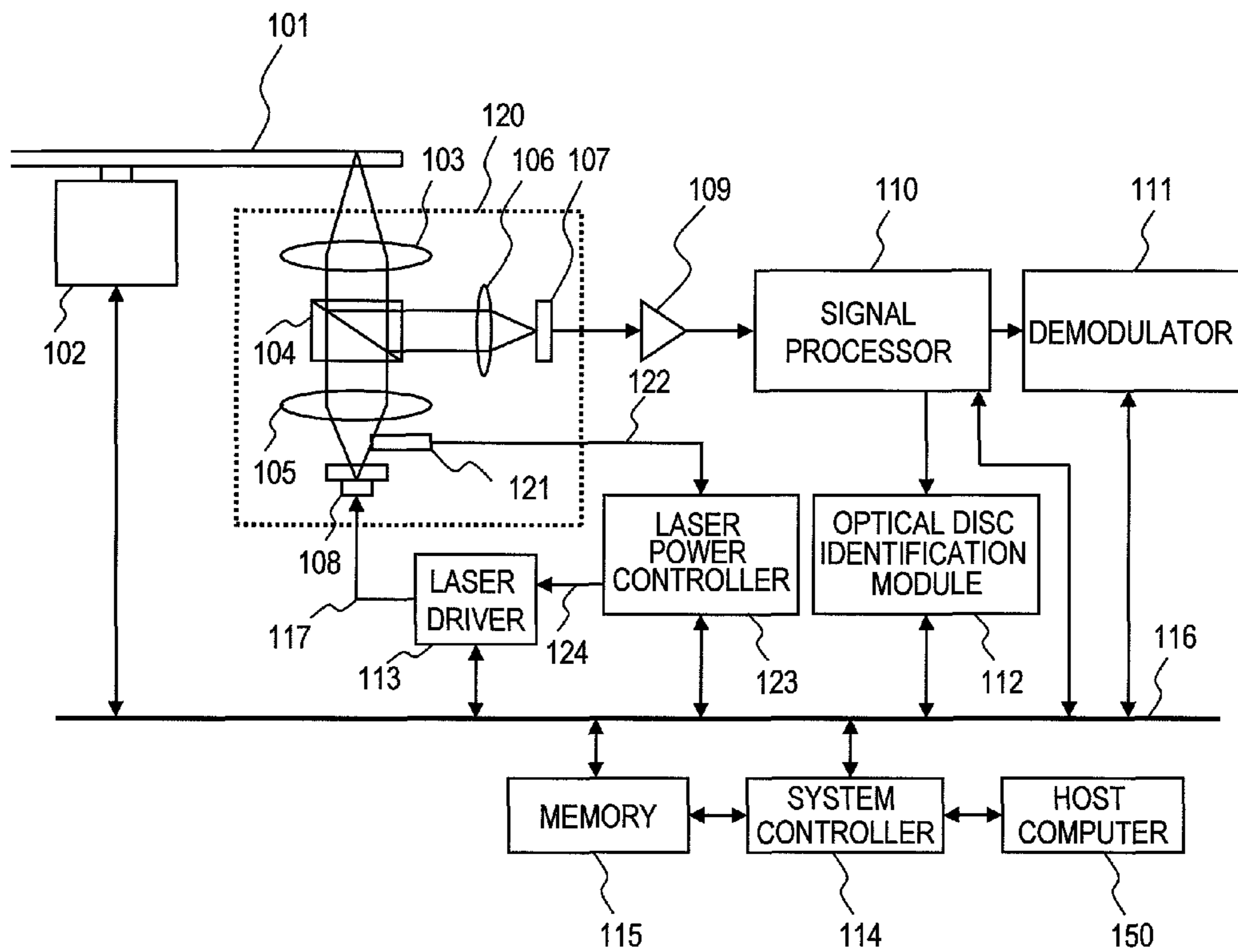


Fig. 1

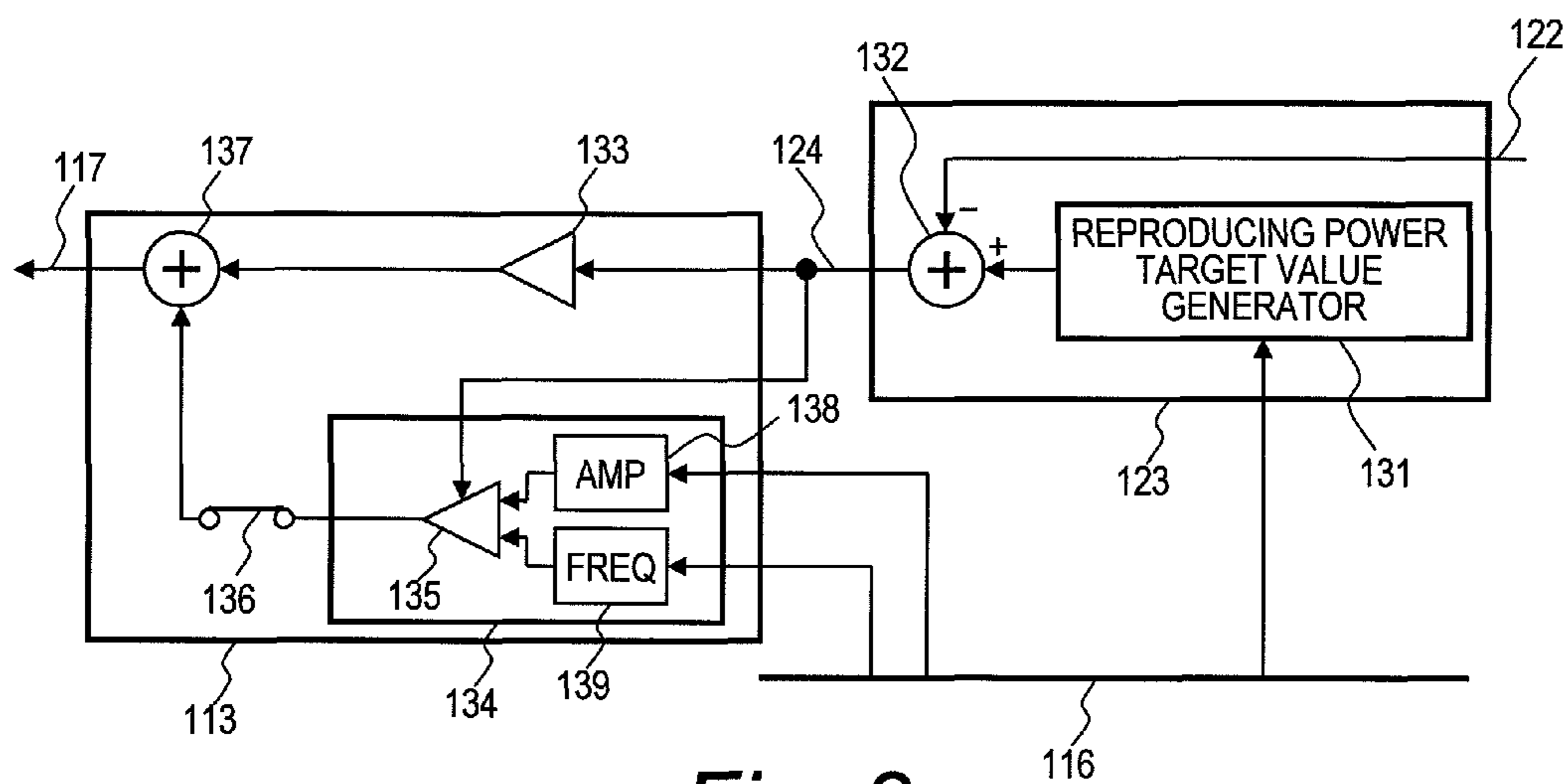


Fig. 2

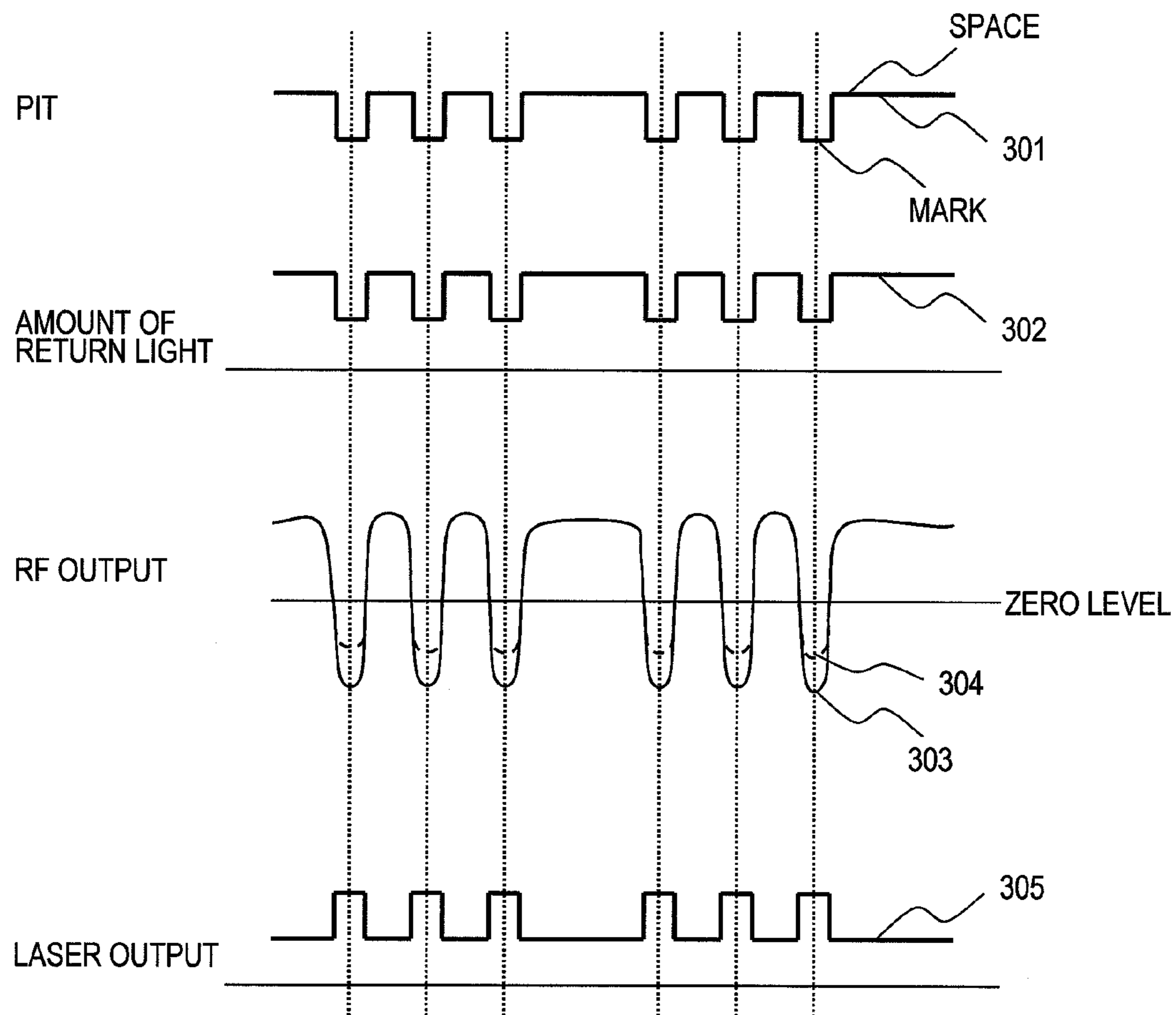


Fig. 3

HF SETTING	0	30
BD-ROM	30	10
BD-R(A)	17	15
BD-R(B)	3	3

Fig. 4

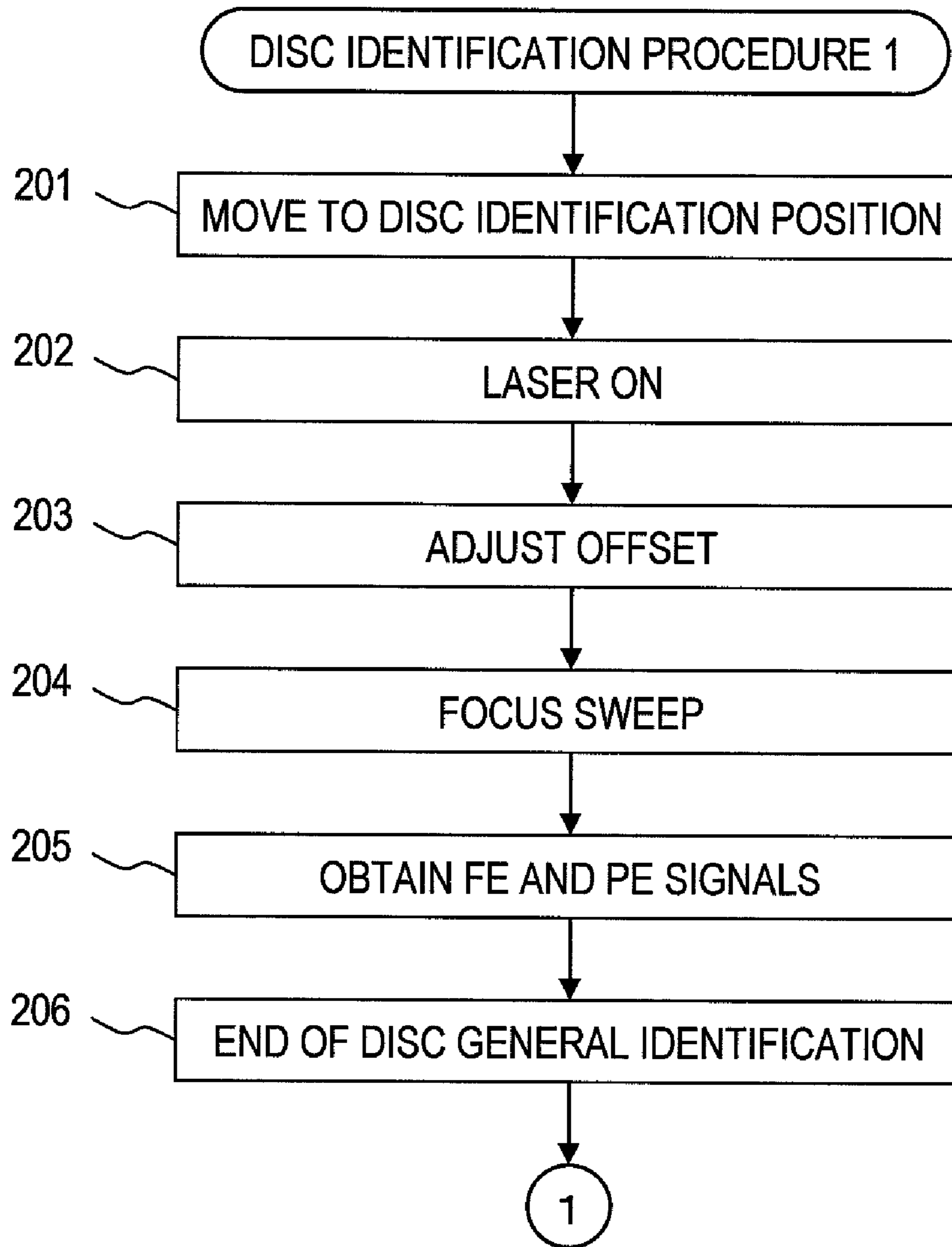


Fig. 5A

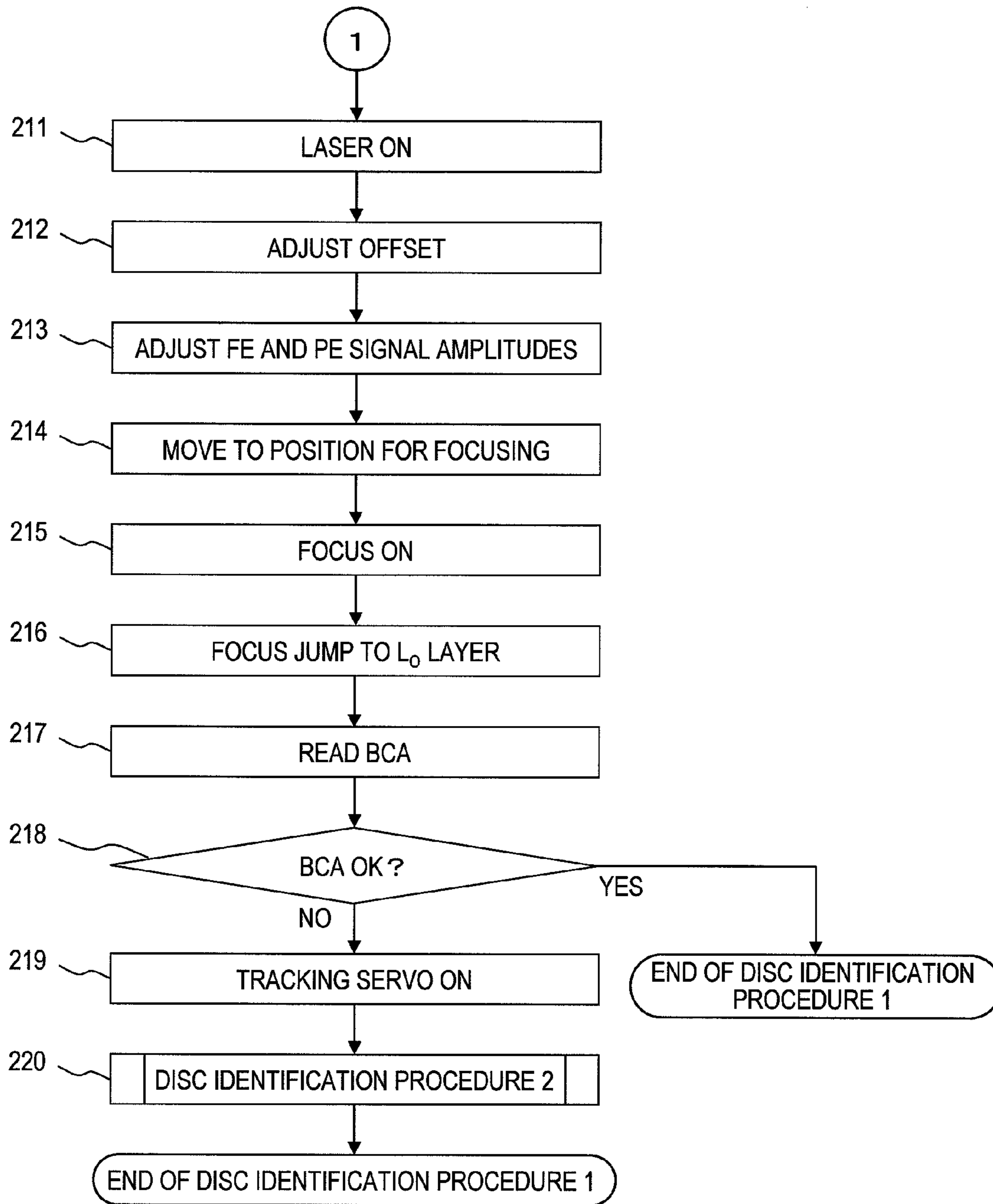


Fig. 5B

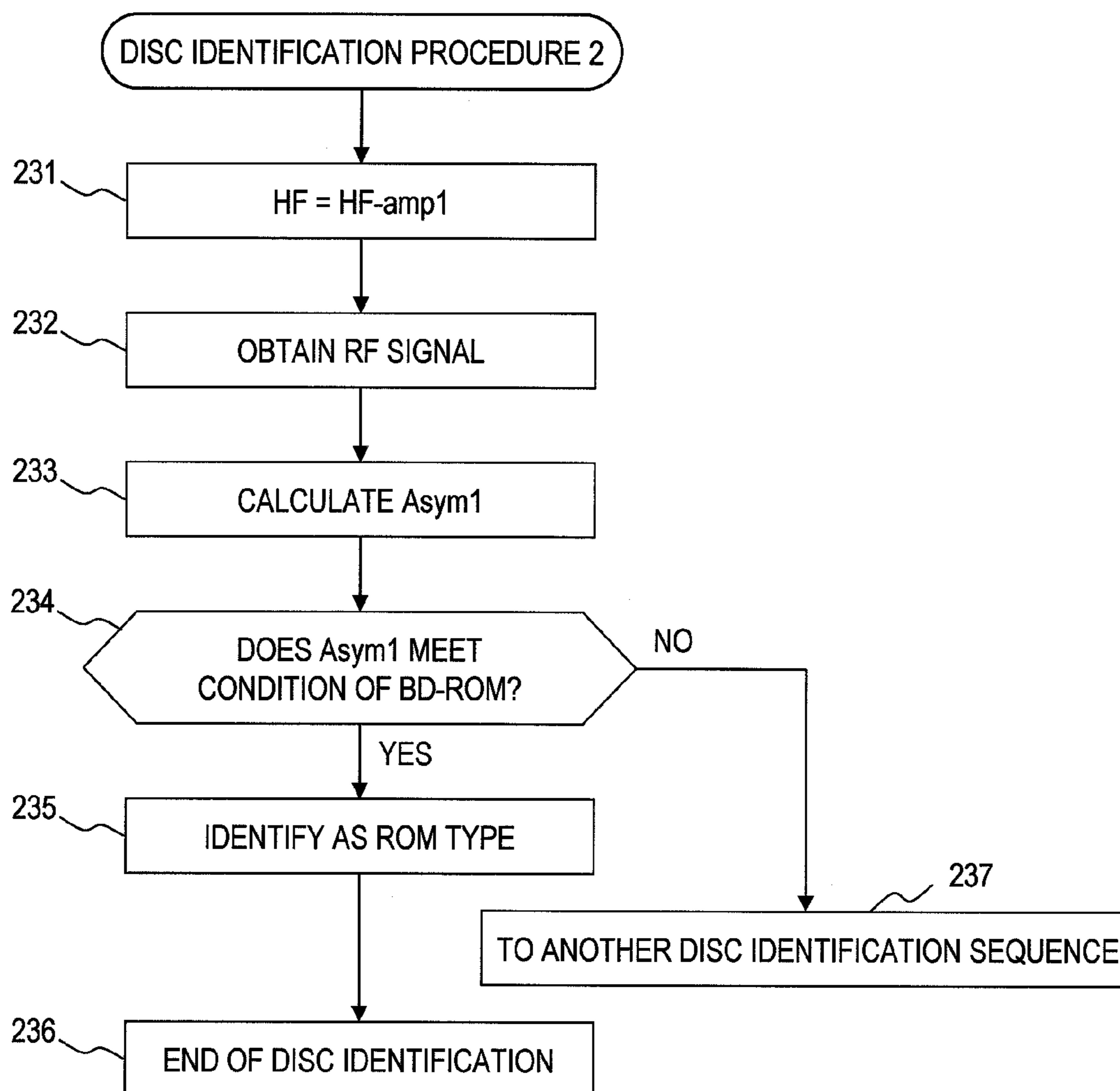


Fig. 6

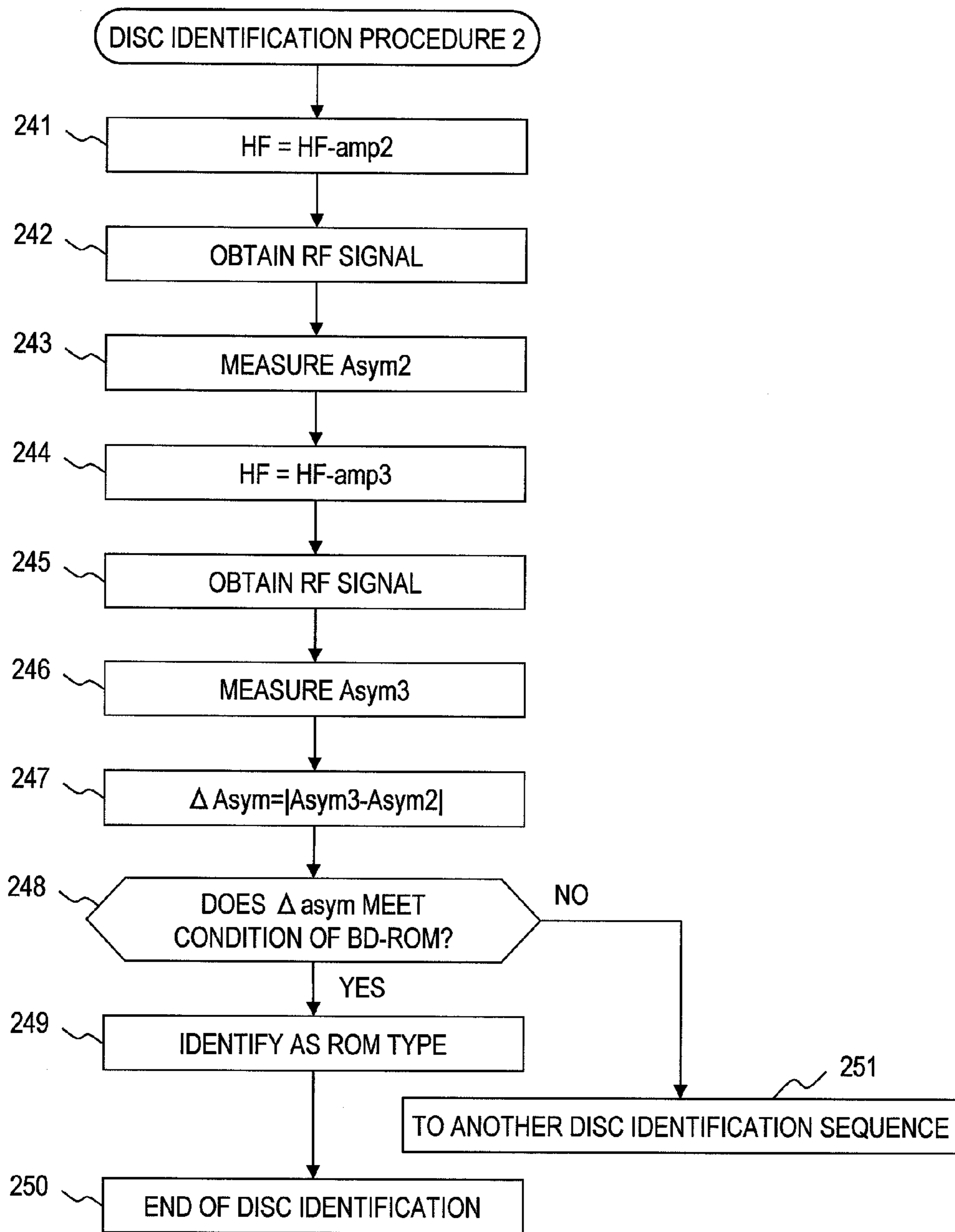


Fig. 7

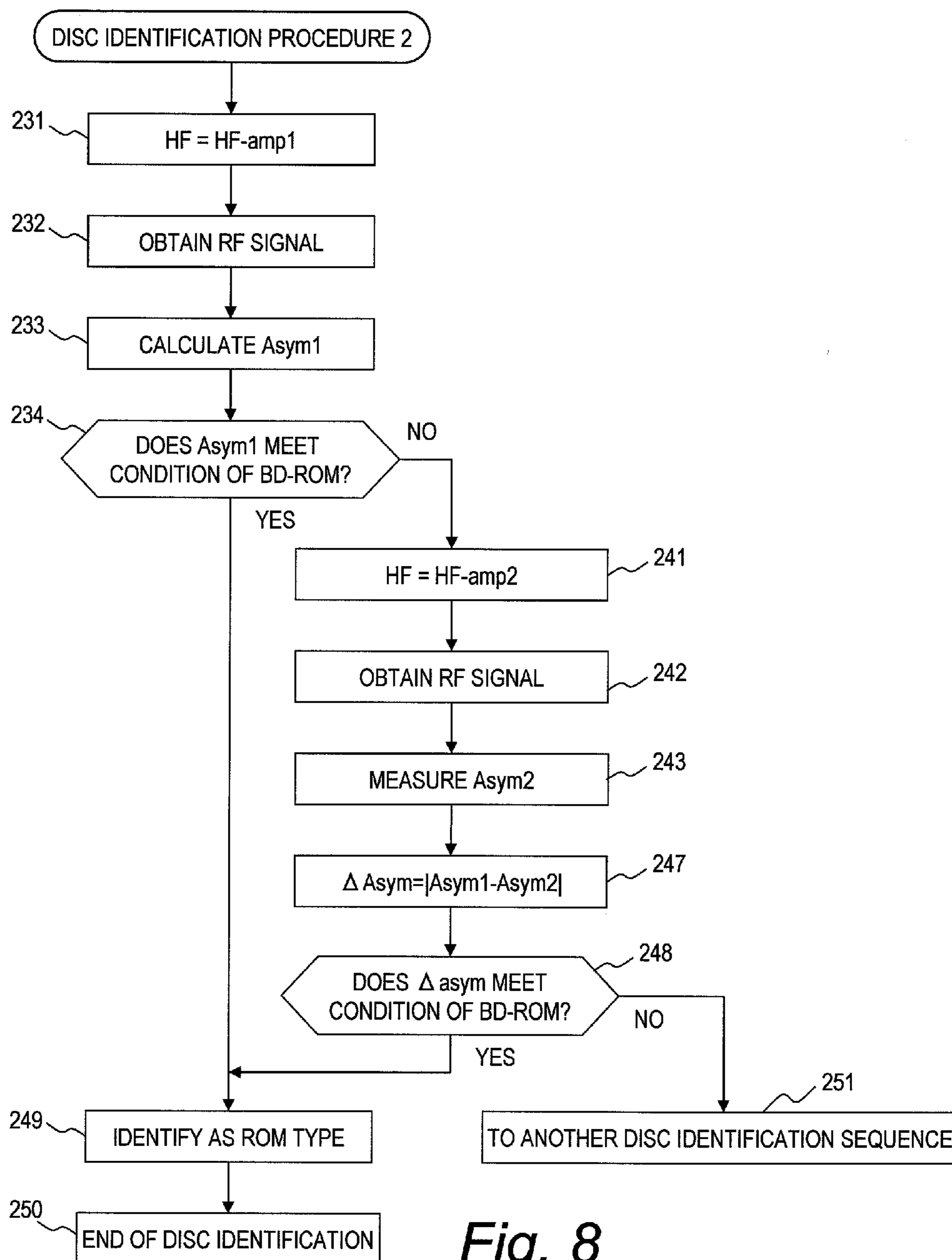


Fig. 8

OPTICAL DISC DEVICE AND DISC IDENTIFICATION METHOD

CLAIM OF PRIORITY

The present application claims priority from Japanese patent application JP 2009-294151 filed on Dec. 25, 2009, the content of which is hereby incorporated by reference into this application.

BACKGROUND OF THE INVENTION

This invention relates to an optical disc device, and in particular, relates to a method of identifying the type of an optical disc loaded therein.

Optical disc is generally classified into CD (Compact Disc), DVD (Digital Versatile Disc), and BD (Blu-ray Disc). Furthermore, there are a plurality of types, such as ROM (read only), -R (writable), and -RE (rewritable), in each kind of disc; playing conditions are different depending on the type of disc. For this reason, an optical disc device is required to identify the type of a disc loaded therein.

Conventionally, optical disc devices identify the type of disc through any one of the following methods to perform playing sequences differing depending on the type of disc:

(1) a method of reading management information recorded in a Burst Cutting Area (BCA) to identify the type of disc by the read management information;

(2) a method of identifying the type of disc by Differential Phase Detection (DPD) amplitude; and

(3) a method of identifying the type of disc by RF amplitude.

For example, JP2007-18581A discloses a technique related to this invention.

As described above, there are various methods for an optical disc device to identify the type of a disc loaded therein. The above-described method (1) enables reliable disc identification because the disc standard stipulates that the type of disc must be recorded in management information (a BCA). Actually, however, there are discs without BCAs. Furthermore, if a BCA is unclean or scratched, the BCA data might be unable to be read from the disc.

DPD is used for tracking adjustment, but tracking adjustment can be made through other methods. Therefore, in an optical disc device which does not employ the DPD, the method (2) cannot be used.

The method using RF signal amplitude utilizes the phenomenon that the intensity of a signal obtained from the return light from a data area, in which data is written, differs depending on the disc, namely, that ROM type discs have greater reflectance and RF amplitude is likely to be larger because of their structure, while -R and -RE type discs have smaller reflectance. However, the reflectance of disc considerably varies among discs, so the identification using reflectance has been less reliable.

For these reasons, the type of a loaded disc sometimes cannot be identified exactly even through the above-described three methods. A method for exactly identifying the type of disc has been desired.

An object of this invention is to provide a method of identifying the type of a loaded disc, particularly whether the disc is a read only (ROM) disc or a writable (-R or -RE) disc.

SUMMARY OF THE INVENTION

A representative aspect of this invention is as follows. That is, there is provided an optical disc device, comprising: a light

source driven by a drive signal with a high frequency signal superimposed; a detector for detecting return light emitted from the light source; and a controller for controlling the amplitude of the high frequency signal to be superimposed on the drive signal, the optical disc device being configured to read data from an optical disc loaded therein by a signal outputted from the detector. The controller causes the light source to irradiate the loaded optical disc with light in a condition in which a high frequency signal different from a high frequency signal for data reading is superimposed on the drive signal. The controller identifies a type of the loaded optical disc based on the return light from the loaded optical disc detected by the detector.

According to an aspect of this invention, a loaded disc can be identified as either a read only disc or a writable disc.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention can be appreciated by the description which follows in conjunction with the following figures, wherein:

FIG. 1 is a block diagram illustrating a configuration of an optical disc device according to an embodiment of this invention;

FIG. 2 is a block diagram illustrating a configuration of a laser driver and a laser power controller according to an embodiment of this invention;

FIG. 3 is an explanatory diagram illustrating a principle that a photoelectric conversion element generates an asymmetric output according to an embodiment of this invention;

FIG. 4 is an explanatory diagram illustrating measured asymmetry outputted from the photoelectric conversion element according to an embodiment of this invention;

FIGS. 5A and 5B are flowcharts of a disc identification procedure 1 in the optical disc device according to an embodiment of this invention;

FIG. 6 is a flowchart of an optical disc identification procedure 2 according to an embodiment of this invention;

FIG. 7 is a flowchart of a first modified example of the optical disc identification procedure 2 according to an embodiment of this invention; and

FIG. 8 is a flowchart of a second modified example of the optical disc identification procedure according to an embodiment of this invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

FIG. 1 is a block diagram illustrating a configuration of an optical disc device 100 according to an embodiment of this invention.

The optical disc device 100 in this embodiment is coupled to a host computer 150 and outputs data read from a loaded optical disc 101 (for example, a Blu-ray Disc) to the host computer 150. The optical disc device 100 may have a function of recording data received from the host computer 150 onto a writable optical disc 101.

The optical disc device in this embodiment comprises a spindle motor 102, an I/V converter 109, a signal processor 110, a demodulator 111, an optical-disc identification module 112, a laser driver 113, a system controller 114, a memory 115, a data bus 116, an optical pickup 120, and a laser power controller 123.

The spindle motor 102 rotates and drives an optical disc 101 loaded in the optical disc device 100.

The optical pickup 120 comprises an objective lens 103, a splitter 104, a collimating lens 105, a collecting lens 106, a

photoelectric converter **107**, a laser beam source **108**, and a monitor diode **121**. When read data from an optical disc **101**, the optical pickup **120** irradiates the optical disc **101** with a weak laser beam, reads data recorded on the optical disc **101** using the reflection of the laser beam (return light), and outputs an RF signal corresponding to the reflection.

The laser beam source **108** is a semiconductor laser that generates a desired intensity of laser beam for recording and playing, and emits a laser beam having a wavelength specified for each type of disc to be loaded. The laser beam emitted from the laser beam source **108** impinges on a specific radial position of the recording surface of the optical disc **101** through the collimating lens **105** and the objective lens **103**. The objective lens **103** is driven by an actuator to adjust the laser beam to be focused on the disc surface.

In recording data onto the optical disc **101**, the laser beam source **108** irradiates the optical disc **101** with a more intensive laser beam than in playing data therefrom. By thermal phase-change at the spot where the laser beam has impinged on the optical disc **101**, a recording pit is formed on the recording layer. The recording pit changes the reflectance of the recording layer to record data. It should be noted that a part of the return light enters the laser beam source **108**.

The laser light reflected on the recording surface of the optical disc **101** is split by the splitter **104**, collected by the collecting lens **106**, and introduced to the photoelectric converter **107**. The photoelectric converter **107** converts the received reflected light into an electric signal (an RF signal) and outputs the RF signal corresponding to the return light.

The monitor diode **121** is for detecting laser power for APC (Automatic Power Control). The signal bandwidth for the monitor diode **121** may be sufficiently low compared with the high-frequency wave which is superimposed on the laser beam in playing. The monitor diode **121** output signal **122** detected by the monitor diode **121** is sent to the laser power controller **123**.

The I/V converter **109** converts a current signal outputted from the photoelectric converter **107** into a voltage signal (an RF signal) and amplifies it. The signal processor **110** is a DSP (Digital Signal Processor), which converts the RF signal outputted from the I/V converter **109** into digital data. The signal processor **110** outputs an optical disc identifier signal differing depending on the structure of the optical disc, a focus error signal for adjusting the focal point of a laser beam, and a tracking error signal for following a track of the optical disc **101**.

The demodulator **111** demodulates the digital data outputted from the signal processor **110** in accordance with the format specified for each type of optical disc, performs error detection and error correction on it, and then temporarily stores the demodulated data in the memory **115** (buffer).

The optical disc identification module **112** identifies the type of the loaded optical disc **101** with reference to the optical disc identifier signal outputted from the signal processor **110**. It should be noted that the optical disc identification module **112** may be constituted by a program to be executed by the system controller **114**.

The identification result on the optical disc **101** outputted from the optical disc identification **112** is sent to the system controller **114** via the data bus **116**. The system controller **114** controls modules to be in optimum conditions (playing conditions and writing conditions) for the identified optical disc based on the identification result of the optical disc.

The laser driver **113** outputs a laser drive signal **117** for driving the laser beam source **108** in the optical pickup **120**. The laser power controller **123** sets laser power target values

in playing and writing in accordance with the type of the optical disc identified by the optical disc identification module **112**.

The system controller **114** comprises a microprocessor for controlling operations of the optical disc device **100** and a memory. The memory in the system controller **114** stores a program to be executed and data necessary for executing the program. The system controller **114** further comprises an interface for controlling sending and receiving of data and commands between the optical disc device **100** and the host computer **150** coupled thereto. The system controller **114** controls reading of data temporarily stored in the memory **115** and writing of data to the memory **115**. The system controller **114** interprets a command received from the host computer **150** and processes the received command.

The memory **115** includes a buffer area in which data read from the optical disc **101** is temporarily stored. The data bus **116** connects modules in the optical disc device **100**.

FIG. 2 is a block diagram illustrating a configuration of the laser driver **113** and the laser power controller **123**.

The laser power controller **123** comprises a playing power target value generator **131** and a subtractor **132**.

First, in accordance with the type of the optical disc **101** identified by the optical disc identification module **112**, the system controller **114** sets a target value of the average laser power for playing the optical disc on a playing power target value generator **131**. The subtractor **132** calculates the difference value **124** between the target value set on the playing power target value generator **131** and the monitor diode's output value **122**. The calculated difference value **124** is sent to the laser driver **113**.

The laser driver **113** comprises an amplifier **133**, a high-frequency signal generator **134**, a switch **136**, and an adder **137**.

The laser driver **113** controls the intensity of the laser beam to be outputted from the laser beam source **108** with the difference value **124** calculated by the laser power controller **123**. This control compensates for a temperature change around the laser beam source **108** and a change in the I/L (current to luminance) ratio caused by degradation over time to achieve stable control of the intensity of the laser beam.

The amplifier **133** amplifies a received difference value **124** and sends the amplified value to the adder **137**.

The high frequency signal generator **134** comprises a variable gain amplifier **135**, an amplitude controller **138**, and a frequency controller **139**, and generates a high-frequency signal to be superimposed onto the laser drive signal **117**.

The amplitude and the frequency of the high-frequency signal to be outputted from the high-frequency signal generator **134**, or the amplitude and the frequency of the high-frequency signal to be superimposed onto the playing laser power, can be determined by the system controller **114**. Specifically, the amplitude controller **138** controls the amplitude of the high-frequency signal to be superimposed with the value determined by the optical disc identification module **112** or the system controller **114**. The frequency controller **139** controls the frequency of the high-frequency signal to be superimposed with the value determined by the optical disc identification module **112** or the system controller **114**.

The variable gain amplifier **135** amplifies an amplitude signal outputted from the amplitude controller **138** and the high-frequency signal outputted from the frequency controller **139** with the gain controlled by the difference value **124** to generate a high-frequency signal having a desired amplitude.

The switch **136** controls on and off of the high-frequency signal generator **134**.

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When the switch **136** is off, the high-frequency signal generator **134** does not output a high-frequency signal, so a high-frequency signal is not superimposed onto the laser output. In this state, the return light, which is light reflected on the surface of the optical disc **101** and incoming into the laser beam source **108**, cause interference with resonance cavity of a laser diode included in the laser beam source **108**. Thus, the laser beam is emitted with an amplitude tremor. Hence, the signal quality (S/N ratio) is degraded.

On the other hand, in the state in which the amplitude of superimposed high-frequency signal is excessive, an erroneous data is recorded on the optical disc **101** and a recording layer of the optical disc degrades in relation of the peak power of the laser beam in which high-frequency signal is superimposed.

Therefore, the amplitude of superimposed high-frequency signal should be adjusted to moderate amplitude.

The adder **137** adds the output of the amplifier **133** and the output of the high-frequency signal generator **134**. The output of the adder **137** is outputted as a laser drive current **117** from the laser driver **113**.

FIG. **3** illustrates a principle that the photoelectric converter **107** generates an asymmetric output.

An optical disc, particularly a ROM-type disc e.g. a BD-ROM, has pits **301** formed by indenting a substrate made of synthetic resin (for example, polycarbonate); the amount of the return light **302** changes around a pit. The photoelectric converter **107** detects the change of the return light to read data from the optical disc. Accordingly, the RF signal **303** outputted from the photoelectric converter **107** varies with the amount of reflection **302** (return light).

In general, the reflectance of an optical disc is higher at a space and the amount of the return light is higher. In contrast, the reflectance is lower at a mark and the amount of the return light is lower. Accordingly, the level of the RF output **303** is higher at a space and lower at a mark. The return light from the optical disc **101** is split by the splitter **104** so as not to return to the laser beam source **108**. Actually, however, a part of the return light passes through the splitter **104** and enters the laser beam source **108** as return light. When the laser light enters the laser beam source **108**, a change in laser output called scoop noise occurs. When a laser beam scans a space, the amount of return light is greater, so that the intensity of the laser beam emitted from the laser beam source **108** diminishes and the RF signal outputted from the photoelectric converter **107** becomes weaker. On the other hand, when a laser beam scans a mark, the amount of return light is smaller, so that the intensity of the laser beam emitted by the laser beam source **108** increases and the RF signal outputted from the photoelectric converter **107** becomes stronger. In this way, the RF signal varies depending on the position of a mark recorded on a disc.

As a result, the level of the RF signal outputted from the photoelectric converter **107** is higher at a space and lower at a mark as indicated by a waveform **304**, which is denoted by a dashed line. Namely, the waveform of the RF output is asymmetric between the positive side and the negative side. This is because oscillation within the laser changes by return light to cause noise, so that the laser output changes.

To avoid the RF output from getting asymmetric in this way, the laser beam emitted by the laser beam source **108** is preferably an intermittent beam modulated with a high-frequency signal, instead of a continuous beam. The intermittent beam can suppress laser noise by reducing the interference between the laser beam and the return light, so that symmetry in the RF output can be maintained.

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The inventors of this invention have found through measurement that the symmetry of the RF signal outputted from the photoelectric converter **107** differs depending on the type of optical disc between when a high-frequency signal is superimposed on the laser beam emitted by the laser beam source **108** and when a high-frequency signal is not superimposed. In particular, ROM-type discs and R-type discs showed remarkably different symmetries (refer to FIG. **4**).

For example, in a BD-ROM disc, the state in continuous radiation (HF OFF) is compared with the state in normal radiation (HF ON). Comparing beta when the HF has been set at a minimum value (HF=0), namely beta in the state of DC playing under the continuous radiation, with beta when the HF has been set at a value for normal playing (HF=30), the value increases by three times. In contrast, in a case of BD-R discs, the values change a little comparing beta when the HF has been set at the minimum value with beta when the HF has been set at 30. Furthermore, when the HF has been set at zero, the beta of the BD-ROM disc is greater than the beta of the BD-R discs.

In the above description, when HF=0, a high frequency signal is not superimposed on the laser drive signal; and when HF=30, it is a normal condition for playing a Blu-ray Disc (a normal data reading state) with a high frequency signal superimposed on the laser drive signal. The data reading state is a state with high frequency wave superimposed, for example, to play management information or user data recorded on the optical disc **101**.

The amount of high frequency signal to be superimposed in this normal playing condition is predetermined depending on the type of disc and the number of layers of the disc; the amount of superimposition is set in accordance with the identified type of the disc. In this connection, the amount of the high frequency signal to be superimposed may be determined after adjusting the predetermined initial value depending on the variation of characteristics of the disc. Adjusting the high frequency signal to meet the normal conditions suitable for playing a disc achieves reduction in laser noise and less error rate (SER: Symbol Error Rate) in playing a disc.

Utilizing the characteristic that the asymmetry of the RF signal changes with the setting of the HF, the type of an optical disc can be identified by measuring the asymmetry of the RF signal outputted from the photoelectric converter **107** with change of the amplitude of the high frequency signal superimposed on the laser beam outputted by the laser beam source **108**.

The asymmetry of the RF signal can be calculated by Beta expressed in the following Expression (1):

$$\text{Beta} = \frac{(B + A)}{(B - A)} \quad (1)$$

In the Expression (1), A represents an amplitude between a positive peak of the RF signal and the zero level and B represents an amplitude between a negative peak of the RF signal and the zero level. In other words, a value of Beta indicates the extent of unbalance between the positive side amplitude and the negative side amplitude with respect to the total amplitude and is expressed by percent. Although the value of Beta is used as an index in writing data, it may be used in playing data.

The asymmetry of the RF signal can also be calculated by a value of Asymmetry expressed in the following Expression (2):

$$\text{Asymmetry} = \frac{(I_{8H} + I_{8L}) - (I_{2H} + I_{2L})}{2 \times I_{8PP}} \quad (2)$$

In the Expression (2), I_{8H} represents a positive peak voltage of the RF output waveform when reading a 8T mark; I_{8L} represents a negative peak voltage of the RF output waveform when reading the 8T mark. I_{8PP} represents a peak-to-peak voltage of the RF power waveform when reading the 8T mark and can be expressed by $I_{8H} - I_{8L}$. I_{2H} represents a positive peak voltage of the RF power waveform when reading a 2T mark and I_{2L} represents a negative peak voltage of the RF power waveform when reading the 2T mark.

Accordingly, the value of Asymmetry is the ratio of the difference between the center of the signal level when reading the longest 8T mark, $(I_{8H} + I_{8L})/2$, and the center of the signal level when reading the shortest 2T mark, $(I_{2H} + I_{2L})/2$, to the peak-to-peak voltage when reading the longest 8T mark, and is expressed by percent.

The value of Asymmetry and the value of Beta are calculated and outputted by the signal processor 110. The outputted Asymmetry (or Beta) is sent to the optical disc identification module 112 and used in optical disc identification, which will be described later.

FIGS. 5A and 5B are flowcharts of a disc identification procedure in the optical disc device 100 in the embodiment of this invention. The procedure disclosed in FIGS. 5A and 5B is executed by the optical disc identification module 112.

To identify an optical disc 101 loaded in the optical disc device 100, the procedure first moves the optical pickup 120 to a position for disc identification (for example, the innermost circumference) (201), and turns on the laser beam source 108 to emit a laser beam with a preset initial wavelength and a preset initial amount of light (202).

Next, an offset voltage to be applied to the photoelectric converter 107 is adjusted based on the amount of the return light received by the photoelectric converter 107 (203).

Then, the objective lens 103 is moved by the actuator, starts a focus sweep (204), and a focus error signal (FE) and an intensity signal (PE) are obtained (205).

The position in thickness where the focus error signal is compared with the intensity signal have been obtained with the specifications of discs to locate the recording layer of the loaded disc, and a type of the loaded disc 101 is identified as either a CD, a DVD, or a BD to end the general identification of the disc (206).

Thereafter, the laser beam source is turned on to emit a laser beam with a wavelength for the general type of disc and in the amount of light preset for the type of disc (211), and the offset voltage to be applied to the photoelectric converter 107 is adjusted based on the amount of the return light received by the photoelectric converter 107 (212).

After that, the objective lens 103 is moved by the actuator, a focus error signal (FE) and an intensity signal (PE) are obtained, and the amplitudes of the obtained focus error signal (FE) and intensity signal (PE) are adjusted to match them to their identification thresholds by adjusting the gain with which the signal processor 110 processes the signals (213).

Next, the optical pickup 120 is moved to a position for focusing (214) and focuses on an arbitrary layer (215). Then, the focus jumps onto the layer for disc identification (216). The layer of the destination of the focus jump is usually the L_0 layer on which the management information (a BCA in a BD, for example) is recorded.

The management information (BCA) recorded on the destination layer (the L_0 layer) (217) is read and it determines

whether the management information has been read properly and whether the management information contains the type of disc (218).

If the read management information includes information about the type of disc, the type of the loaded disc is identified, the disc identification procedure is terminated, and a procedure of playing the disc is started.

On the other hand, if the type of disc has not been read, namely, if the management information is not read properly, or if the read management information does not include the type of disc, a disc identification procedure 2 is prepared to execute.

Specifically, it starts a tracking servo to prepare for properly reading data recorded on the disc (219). It should be noted that the tracking servo may be off in measurement of the asymmetry. Then, the disc identification procedure 2 is started (FIGS. 6 and 7) (220).

FIG. 6 is a flowchart of an optical disc identification procedure 2 in the embodiment of this invention; the procedure is executed by the optical disc identification module 112.

First, the optical disc identification module 112 sets the amplitude of the high frequency signal HF-amp 1 on the high frequency signal generator 134 and irradiates the optical disc 101 with a laser beam on which the high-frequency signal is superimposed (231). The HF-amp1 is preferably an amplitude of a high-frequency signal which is not for data reading. For example, it may be a minimum amplitude settable to the optical disc device 100 (for example, zero), which is different from the value in normal data reading. This is because, if the amplitude of the superimposed high-frequency signal is zero, the asymmetry of the RF signal outputted from the photoelectric converter 107 will be greatest.

Next, the photoelectric converter 107 receives the return light from the optical disc 101 and outputs an RF signal (232). The signal processor 110 calculates the value of Asymmetry from the RF signal outputted by the photoelectric converter 107 and sends the calculated value of Asymmetry to the optical disc identification module 112 (233).

The optical disc identification module 112 compares the value of Asymmetry (Asym1) of the RF signal outputted from the photoelectric converter 107 with a predetermined threshold to identify the type of the loaded optical disc (234). The threshold is preferably a value with a given margin added to the maximum value which is acceptable to the specification as asymmetry.

In the identification, if the value of Asymmetry is greater than the predetermined threshold, the loaded optical disc is defined as a read only ROM type disc (235), and the optical disc identification procedure is terminated, and the procedure returns to the optical disc identification procedure 1 (236). On the other hand, if the value of Asymmetry is the predetermined threshold value or less, the type of the loaded disc cannot be identified. Therefore, the procedure returns to the optical disc identification procedure 1 and the type of optical disc will be identified by another sequence (237).

As described above, according to the optical disc identification procedure 2 illustrated in FIG. 6, one measurement of Asymmetry after changing the amplitude of the high frequency signal enables the identification of the type of disc, providing a speedy identification of the type of disc.

FIG. 7 is a flowchart of a first modified example of the optical disc identification procedure 2 in the embodiment of this invention.

First, the optical disc identification module 112 sets the amplitude of the high frequency signal HF-amp2 on the high-frequency signal generator 134 and irradiates the optical disc 101 with a laser beam in which the high-frequency signal is

superimposed (241). This HF-amp2 is preferably a normal amplitude of the high frequency signal which has been predetermined for the general type of optical disc. This setting of the HF-amp2 to meet the optimum read condition provides a waveform suitable for identification.

Next, the photoelectric converter 107 receives the return light from the optical disc 101 and outputs an RF signal (242). The signal processor 110 calculates the Asymmetry (Asym2) from the RF signal outputted from the photoelectric converter 107 and sends the calculated Asymmetry to the optical disc identification module 112 (243).

The optical disc identification module 112 sets an amplitude of the high frequency signal HF-amp3 on the high-frequency signal generator 134 and irradiates the optical disc 101 with a laser beam in which the high frequency signal is superimposed (244). The HF-amp3 is preferably an amplitude of the high-frequency signal which is not for data reading. For example, it may be a minimum amplitude settable to the optical disc device 100 (for example, zero), which is different from the value in normal data reading. This is because, if the amplitude of the superimposed high-frequency signal is zero, the asymmetry of the RF signal outputted from the photoelectric converter 107 will be greatest.

Next, the photoelectric converter 107 receives the return light from the optical disc 101 and outputs an RF signal (245). The signal processor 110 calculates the value of Asymmetry (Asym3) from the RF signal outputted by the photoelectric converter 107 and sends the calculated value of Asymmetry to the optical disc identification module 112 (246).

With respect to the order of the measurements, the measurement of Asym3 may precede the measurement of Asym2.

The optical disc identification module 112 obtains the difference (Δ Asym) between the value of Asymmetries Asym2 and Asym3 of the RF signal obtained under different conditions of high frequency superimposition (247). Then the obtained difference of Asymmetries (i.e. a variation of Asymmetries) is compared with a predetermined threshold to identify the type of the loaded optical disc (248). This threshold is preferably set at the value obtained by deducting a predetermined margin from a value approximate to the maximum value or the maximum value of the asymmetry acceptable to the specification.

In the identification, if the variation of the asymmetry is more than the predetermined threshold, the optical disc identification module 112 identifies the loaded optical disc as a ROM type disc (249), and terminates the optical disc identification procedure, and the procedure returns to the optical disc identification procedure 1 (250). On the other hand, if the variation of Asymmetry is less than or equal to the predetermined threshold, the type of the loaded optical disc cannot be identified. Therefore, the procedure returns to the optical disc identification procedure 1 and the type of optical disc will be identified by another sequence (251).

As described above, according to the first modified example illustrated in FIG. 7, the type of disc is identified by the variation of Asymmetry caused by changing the amplitude of the high frequency signal, so the type of the loaded disc can be identified even if the amplitude is zero or in the Asymmetry ranges of the specification (under the threshold at 234).

FIG. 8 is a flowchart of a second modified example of the optical disc identification procedure in the embodiment of this invention.

The second modified example is an optical disc identification procedure of the combination of the procedure illustrated in FIG. 6 and the first modified example illustrated in FIG. 7.

Namely, first, the optical disc identification procedure illustrated in FIG. 6 (231 to 235) is executed. If the type of the loaded optical disc cannot be identified, the steps 241 to 243 and 247 to 251 in the modified example illustrated in FIG. 7 are executed. Since the steps 244 to 246 of the modified example illustrated in FIG. 7 are the same as the steps 231 to 233 in the optical disc identification procedure illustrated in FIG. 6, it is not necessary to measure the asymmetry without the high frequency superimposed in steps 244 to 246; a simplified procedure is achieved.

Although the procedures illustrated in FIGS. 5A, 5B, 6, 7, and 8 have been described to be executed by the optical disc identification module 112, they may be executed by the system controller 114.

The procedures described above use the value of Asymmetry to identify the type of disc, but may use another value (Beta) indicating asymmetry. Otherwise, instead of the asymmetry of the RF output, the amplitude of the RF output may be used to identify the type of disc. This is because, if the asymmetry is found, the amplitude of the RF output will be smaller.

As described above, according to the embodiment of this invention, the symmetry of the RF signal outputted from the photoelectric converter 107 is measured with change of the amplitude of the high frequency signal to be superimposed on the laser beam emitted by the laser beam source 108, or the amplitude of the high frequency signal superimposed on the laser drive signal. Since the type of disc is identified by variation of symmetry of the RF signal caused by changing the amplitude of the high frequency signal, the disc identification is achieved with high reliability.

While the present invention has been described in detail and pictorially in the accompanying drawings, the present invention is not limited to such detail but covers various obvious modifications and equivalent arrangements, which fall within the purview of the appended claims.

What is claimed is:

1. An optical disc device, comprising:

a light source driven by a drive signal with a high frequency signal superimposed;
a detector for detecting return light emitted from the light source; and

a controller for controlling the amplitude of the high frequency signal to be superimposed on the drive signal, the optical disc device being configured to read data from an optical disc loaded therein by a signal outputted from the detector, wherein:

the controller causes the light source to irradiate the loaded optical disc with light in a condition in which a high frequency signal different from a high frequency signal for data reading is superimposed on the drive signal;

the controller identifies a type of the loaded optical disc based on the return light from the loaded optical disc detected by the detector;

the controller measures a first asymmetry from an output of the detector without a high frequency signal superimposed on the drive signal; and

the controller identifies the type of the loaded optical disc as either a writable disc or a read only disc based on a comparison result of the measured first asymmetry with a predetermined threshold.

2. The optical disc device according to claim 1, wherein: the controller measures a second asymmetry of an output from the detector with a high frequency signal for data reading superimposed in a case where the type of the loaded optical disc cannot be identified based on the measured first asymmetry; and

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the controller identifies the type of the loaded optical disc as either a writable disc or a read only disc based on a comparison result of the difference between the measured first asymmetry and the measured second asymmetry with a predetermined threshold.

3. The optical disc device according to claim 1, wherein: the optical disc device reads information of the type of disc from a management information recording area of the loaded optical disc; and

the controller identifies the type of the loaded optical disc as either a writable disc or a read only disc by using the measured first asymmetry in a case where the type of the loaded disc cannot be identified based on the read information.

4. The optical disc device according to claim 1, wherein: the controller measures a first asymmetry of an output from the detector without a high frequency signal superimposed on the drive signal;

the controller measures a second asymmetry of an output from the detector with a high frequency signal for data reading superimposed; and

the controller identifies the type of the loaded optical disc as either a writable disc or a read only disc based on a comparison result of the difference between the measured first asymmetry and the measured second asymmetry with a predetermined threshold.

5. The optical disc device according to claim 4, wherein: the optical disc device reads information of the type of disc from a management information recording area of the loaded optical disc; and

the controller identifies the type of the loaded optical disc as either a writable disc or a read only disc by using the measured first asymmetry and the measured second asymmetry in a case where the type of the loaded disc cannot be identified based on the read information.

6. A disc identification method executed in an optical disc device which has a light source driven by a drive signal with a high frequency signal superimposed, a detector for detecting return light emitted from the light source, and a controller for controlling the amplitude of the high frequency signal to be superimposed onto the drive signal and reads data from an optical disc loaded therein by a signal from the detector, including the steps of:

irradiating, by the light source, the loaded optical disc with light in a condition in which a high frequency signal different from a high frequency signal for data reading is superimposed on the drive signal;

identifying, by the controller, a type of the loaded optical disc based on the return light from the loaded optical disc detected by the detector,

measuring, by the controller, a first asymmetry of an output from the detector without a high frequency superimposed on the drive signal; and

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identifying, by the controller, the type of the loaded optical disc as either a writable disc or a read only disc based on a comparison result of the measured first asymmetry with a predetermined threshold.

7. The disc identification method according to claim 6, further including the steps of:

measuring, by the controller, a second asymmetry of an output from the detector with a high frequency signal for data reading superimposed in a case where the type of the loaded optical disc cannot be identified based on the measured first asymmetry; and

identifying, by the controller, the type of the loaded optical disc as either a writable disc or a read only disc based on a comparison result of the difference between the measured first asymmetry and the measured second asymmetry with a predetermined threshold.

8. The disc identification method according to claim 6, further including the steps of:

reading, by the optical disc device, information of the type of disc from a management information recording area of the loaded optical disc; and

identifying, by the controller, the type of the loaded optical disc as either a writable disc or a read only disc by using the measured first asymmetry in a case where the type of the loaded disc cannot be identified based on the read information.

9. The disc identification method according to claim 6, further including the steps of:

measuring, by the controller, a first asymmetry of an output from the detector without a high frequency signal superimposed on the drive signal;

measuring, by the controller, a second asymmetry of an output from the detector with a high frequency signal in data reading superimposed; and

identifying, by the controller, the type of the loaded optical disc as either a writable disc or a read only disc based on a comparison result of the difference between the measured first asymmetry and the measured second asymmetry with a predetermined threshold.

10. The disc identification method according to claim 9, further including the steps of:

reading, by optical disc device, information of the type of disc from a management information recording area of the loaded optical disc; and

identifying, by the controller, the type of the loaded optical disc as either a writable disc or a read only disc by using the measured first asymmetry and the measured second asymmetry in a case where the type of the loaded disc cannot be identified based on the read information.

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